Plant Pathology Circular No. 314
December 1988
Rev. Circ. No. 214

Fla. Dept. Agric. & Consumer Serv.
Division of Plant Industry

PHYTOPHTHORA ROOT ROT OF SAND PINE

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Sand pine (Pinus clausa (Chapm.) Vasey) is a relatively small, short-lived, southern yellow pine native to Florida's sandhills. Botanists and foresters generally recognize two distinct varieties; Choctawhatchee (P. clausa var. immuginata Ward), native to Florida's western panhandle, and Ocala (P. clausa var. clausa), native to peninsular Florida. Interest in commercial management of sand pine is heightened by its potential as a Christmas tree and its ability to grow well on deep, droughty, infertile, acid, sands - sites on which other commercially important tree species develop poorly if at all.

The fungus, Phytophthora cinnamomi Rands, is a soil-borne pathogen which affects more than 900 plant species (4,7,9,10,15,16,18). In the southern United States, P. cinnamomi is well known to foresters for its involvement in littleleaf disease of Pinus spp., particularly shortleaf pine (P. echinata Mill.) (4,6,15). The fungus has also played significant roles in the demise of the American chestnut Castanea dentata (Marsh.) Borkh.) (7), the devastation of some 100,000 hectares (247,000 acres) of jarrah (Eucalyptus marginata Donn. ex Sm.) forests in western Australia (10,11,12), and root diseases on a variety of commercially important tree species in forest nurseries in the United States (4,7,9). In 1972, Ross and Marx (14) confirmed that P. cinnamomi is pathogenic to seedlings of sand pine. After 2 months in greenhouse tests the pathogen killed up to 96 and 60% of test seedlings of the Choctawhatchee and Ocala varieties, respectively.

Field observations (1,13,14) have revealed P. cinnamomi to be commonly associated on sand pine with other known and/or suspected root pathogenic fungi. In north and north-central Florida P. cinnamomi is the most frequently occurring root pathogenic fungus in plantations and seed orchards with root disease (1). Interestingly however, the occurrence of the fungus in natural stands of sand pine has yet to be documented (1,13,14).

In Florida, approximately 500,000 sand pine seedlings were destroyed in one commercial forest nursery in 1978-79 due to outright mortality caused by P. cinnamomi and/or related quarantine of infected stock (author, unpublished). Recent work (3) has verified the capability of the fungus to cause reduced growth and mortality of sand pine in plantations due to nursery-to-field transfer (i.e., carry-over) of the pathogen on roots of infected nursery stock. In a more recent and ongoing study (2), mortality of pathogen-free sand pine planted on a P. cinnamomi-infested deep Lakeland sand in west Florida continues to be progressive and excessive due to post-outplant infections by the pathogen.

The complete role of P. cinnamomi in the etiology and epidemiology of sand pine root disease is not yet fully understood, particularly in stands where it occurs in association with other known or suspected root disease fungi. However, its documented pathogenicity, known distribution, and infamous history make this pathogen one of substantial importance to timber industries and others engaged in growing sand pine.

ORIGIN AND DISSEMINATION. The origin of P. cinnamomi is uncertain, but considerable evidence suggests that it may be an introduced pathogen in the United States, as it well may be in the jarrah forests of western Australia (6,10,11,12,16,17,18). The fact that it has been found only in planted sand pine stands and not in natural stands supports this view. The extent to which P. cinnamomi has spread into the sandhills of Florida and the Southeastern U.S. is unknown. P. cinnamomi, like other soil-borne fungi, can be spread by movement of infected nursery stock, movement of infested soil on equipment, surface movement of irrigation or rainwater, and mycelial growth through contiguous root systems of suitable host plants (9,10,16,17,18). The pathogen is capable of surviving for years in infested soils in the absence of a suitable host (9,16,18).

SYMPTOMS & RECOGNITION. In nursery seedbeds, severely infected seedlings exhibit foliage discoloration ranging from a slight chlorosis to bright orange-red or brown with the onset of mortality (Fig. 1). Wilting of foliage and succulent growing tissues may also occur. Seedlings which are only lightly infected often fail to exhibit noticeable aboveground symptoms or simply remain stunted. Infected roots (Fig. 2) are typically darkened, and the necrotic cortical tissues of infected feeder roots are characteristically prone to sloughing, exposing the woody tissues of the stele. Adventitious root development, at points behind the advancing necrosis, is not uncommon. Occasionally, tap roots and root collars are partially or fully impregnated with resin. This symptom may or may not be accompanied by external resinosis.

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Fig. 1. Mortality of sand pine due to root infections by Phytophthora cinnamomi; A) first-year seedlings in a bare- root forest tree nursery, B) 4-year-old plantation.

Fig. 2. Roots of sand pine infected with Phytophthora cinnamomi. A) Roots of nursery seedlings. Note lack of short lateral roots and presence of black, necrotic and sloughing cortical tissues. B) Resin-soaked tap root of seedling infected during its first year in the field.

In the field, infected trees exhibit the same pattern of aboveground symptom development, although by virtue of seedling or tree size and other environmental factors, the interval between the onset of initial symptoms and eventual mortality may be extended. Some infected trees remain green, but show symptoms of decline or stress by **a** progressive thinning of their crowns (Fig. 1). Infected roots in field situations usually exhibit some degree of external resinosis, and as a result, soil often adheres in clumps to roots of diseased trees. Sometimes external resinosis is evident on the stems at or near the ground line. Internally, woody roots and root collars of diseased trees generally show some degree of resin impregnation (Fig. 2). With increasing stand age, diseased trees become increasingly susceptible to windthrow due to the progressive loss of roots vital to their support. At this stage the involvement of other known or suspected root rot pathogens is common, and the specific roles of each in the root disease complex are less than completely understood.

Because only symptoms of P. cinnamomi infections are evident in nursery and field situations and these symptoms are not pathogen-specific, laboratory confirmation is essential for positive diagnosis.

CONTROL STRATEGIES.

1. Sound management and sanitation practices in forest and ornamental nurseries to reduce risks of introduction and spread of P. cinnamomi to uninfested soils.

2. Depending upon soil conditions, disease histories, logistics, and alternative production capabilities, give serious consideration to terminating production of sand pine in bare-root forest nurseries with resident populations of P. cinnamomi.

3. Where proven effective, fumigate nursery soils with an appropriate formulation and rate of methyl bromide.

4. Spread of infections in nursery settings may be slowed or prevented with the judicious application of appropriately labeled fungicides.

5. Regulatory methods including meticulous inspection and phytosanitary certification of nursery seedling crops, with the application of rigid quarantines where appropriate.

6. Do not move, ship, or outplant infected nursery stock.

7. Avoid planting sand pine in locations and/or environments which are conducive to the activity of the pathogen (e.g.,fine textured, poorly drained soils or soils with a shallow impervious layer) or where P. cinnamomi is known to occur.

8. Avoid contamination of planting sites via soil movement. Adequately clean machinery, etc., which has been operating in areas of known pathogen activity.

9. Consider alternative, apparently less susceptible species (e.g., slash or longleaf pines) when regenerating sites where the pathogen's presence is known and such alternatives are silviculturally acceptable. Longleaf pine is performing very well and is apparently resisting infections in a test planting on a P. cinnamomi-infestedsandhill in west Florida (author, unpublished).

10. Future gains may be possible through the identification of sand pine genotypes with resistance to P. cinnamomi. Genetic resistance to P. cinnamomi has been reported for Pinus radiata D. Don (5) and indications of possible resistance within sand pine have been observed (8).

SURVEY & DETECTION. Look for discoloration, resinosis, necrosis, and sloughing of cortical tissues on fine roots of dead/dying sand pine. Examine woody roots for evidence of resin exudations possibly giving rise to adhering clumps of resin-impregnated soil. Examine internal tissues of woody roots for distinct and profuse resin-soaking. Laboratory isolation of P. cinnamomi is required for confirmation.

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Contribution No. 635, Bureau of Plant Pathology

This publication was issued at a cost of $1286.76 or $ 0.29 per copy to provide information on proper recognition of plant pests. P189T-02